

Assessment of Impact of the December 26 2004 Tsunami In Aceh Province Indonesia

Center for Global Change and Earth Observations

Information assistance and cooperation with

The Tropical Rain Forest Information Center, Michigan State University
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Background

On December 26, 2004 at 7:58 AM local time a major earthquake measuring 9.0 occurred in the Indian Ocean off the coast of Sumatra, Indonesia. The quake occurred in the highly seismic zone of the Burma Microplate (Figure 1) in an area known as the Sunda Trench (more background tectonic information can be found at <http://earthquake.usgs.gov/eqinthenews/2004/usslav/>) where the India plate begins its subduction under the Sunda plate. The quake created a very large displacement of ocean water resulting in a Tsunami that impacted coastal areas throughout the Indian Ocean. Hardest hit were the countries of Indonesia, Sri Lanka, India and Thailand. The death toll at this writing exceeds 100,000 people and is major disaster of monumental geographic and human proportions.

Unlike many disasters the *geographic* impact of this tsunami was large. It is difficult to fully and accurately ascertain the area affected, gauge the geographic extent of the impact, or know precisely what locations were affected most. Reports from the field indicate that Aceh Province in Indonesia were hardest hit and probably suffered the highest loss of life. But within the Province it is difficult to know locations where the tsunamai impact was greatest without a regional impact map.

We acquired Landsat data from an overpass on December 29, 2004 and compared these images with pre-disaster images we have in our archive at www Landsat.org. These images were geographically co-registered and color enhanced to reveal areas of inundation and destruction for most of the Province. From these paired images (ie before and after pairs), image maps were developed to show where the impact was located. These data were sent to colleagues in the Indonesian government to help in relief efforts.

Summary of Results

Aceh Province is located in the northern tip of Sumatra (Figures 2a and 2b). This analysis is for the north half of the province only, due to availability of data. The costal margins of the islands of Indonesia are some of the most populated areas in the world

(Figure 3). Moreover, most of the people living in Aceh Province live along a coastal ribbon within 5 kilometers of the ocean.

Areas most significantly affected were in the heavily populated cities. The tsunami inundation and damage was not uniform as seen in Figures 4-8. The geographic orientation of impact reflects the geomorphology of the land mass as well as the bathymetry beneath the water close to the shoreline. Some areas were hard hit such as Lho-nga, which as shown in Figure 4 was completely swamped by water. It appears a large mass of water pushed over the land by force and did not recede. Cities and heavily populated areas also happened to be in target areas of high impact. Also not the effect on the major city of Meulaboh (Figure 8), which because of its geographic position was completely inundated and an area of extreme human impact.

Our assessment suggests the need for immediate relief to the identified areas on the image maps in Figures 4 and 5 and Figure 8. In particular: Banda Aceh, Lho-nga, Baba nipah area, Meulaboh, and Udjun Muloh.

Unlike other types of disasters, such as hurricanes, the area impacted by the tsunami was not large when compared to the total area of the province. Our analysis of images indicate significant damage inland from the coast for only about 1-2 km for most of the coastline, but up to 3-5 km in low areas and around the provincial capitol of Banda Aceh, which is located in a low lying area. Using image processing and GIS we estimate and map the total area of damage. The total area extent of impact was 413 km², which is a small percent of the total provincial area. These damage assessment maps are given in Figures 9-12. However, because of the high population densities in this narrow coastal zone the human impact was nonetheless extremely large.

In conclusion it is important to note that while this tsunami was unusually large, and that its magnitude contributed significantly to its heavy toll, it is also true that other factors contributed to the great loss of life. As development of the coastal margins has grown, its vulnerability has also increased. More people are living in the high risk zones. Moreover, what is becoming clear from reports in the field is that the most affected segments of the population are the poor, young and elderly. As marginalized and poor segments of the population inhabit these hazard prone areas, increased vulnerability is placed disproportionately on disadvantaged segments of the population.

Although the impact of the Tsunami was sudden in Aceh, it is generally clear that early warning systems could have had a considerable ability to reduce vulnerability, since moving only a few kilometers from the coastline would reduce an individual's risk significantly, as our mapping shows. The new Earth Observations initiative led through the GEOSS initiative should work hard to make earth observations assets available to all countries. The science and technology exist; the Earth Observation community can do a lot more to prevent such disasters in the future, but resources and priorities need to be placed on developing the necessary tools and protocols to take advantage of the technology and assets.

M9.0 Sumatra - Andaman Islands Earthquake of 26 December 2004

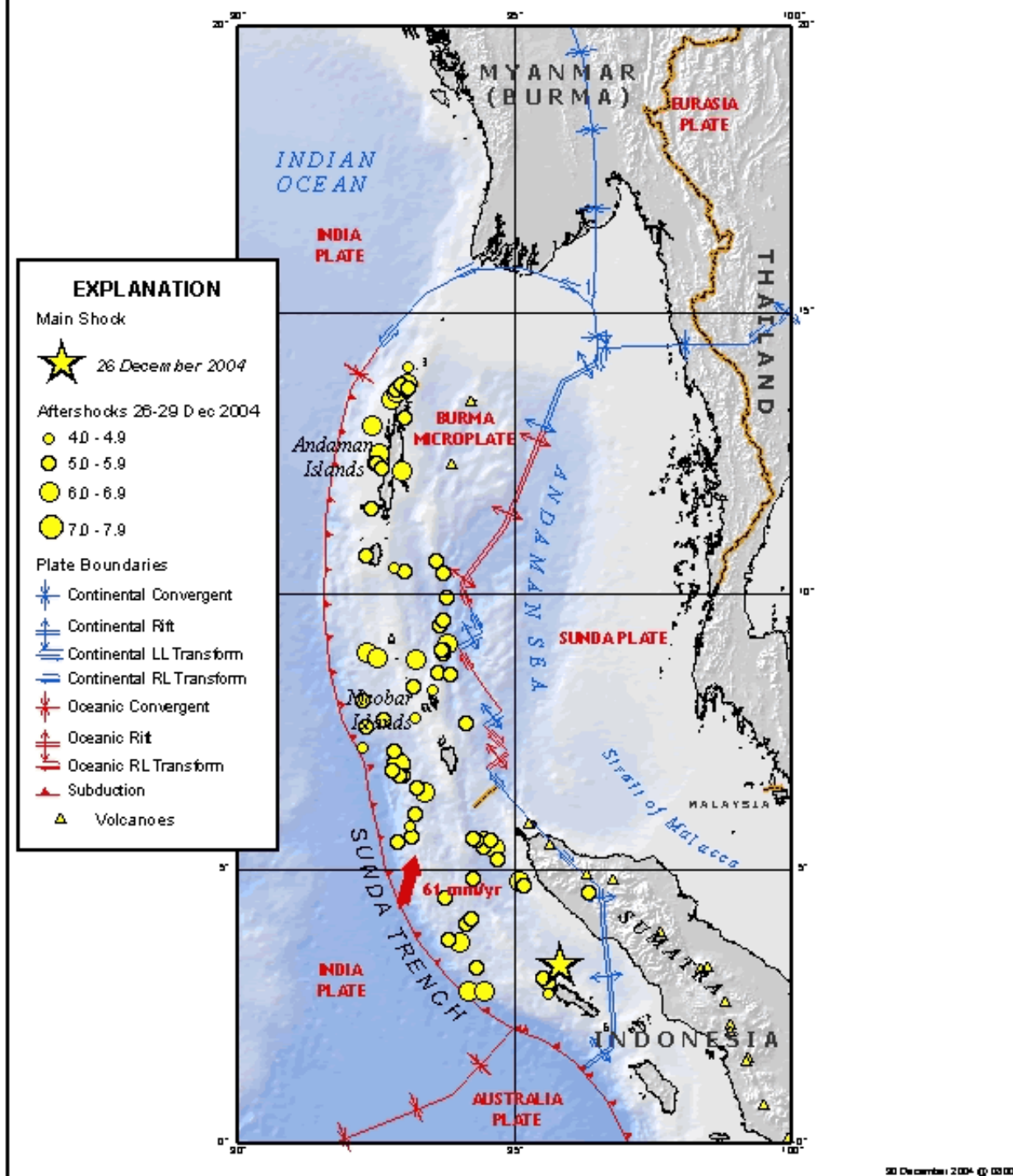


Figure 1. Geologic characterization of the region. Epicenter shown with a star.

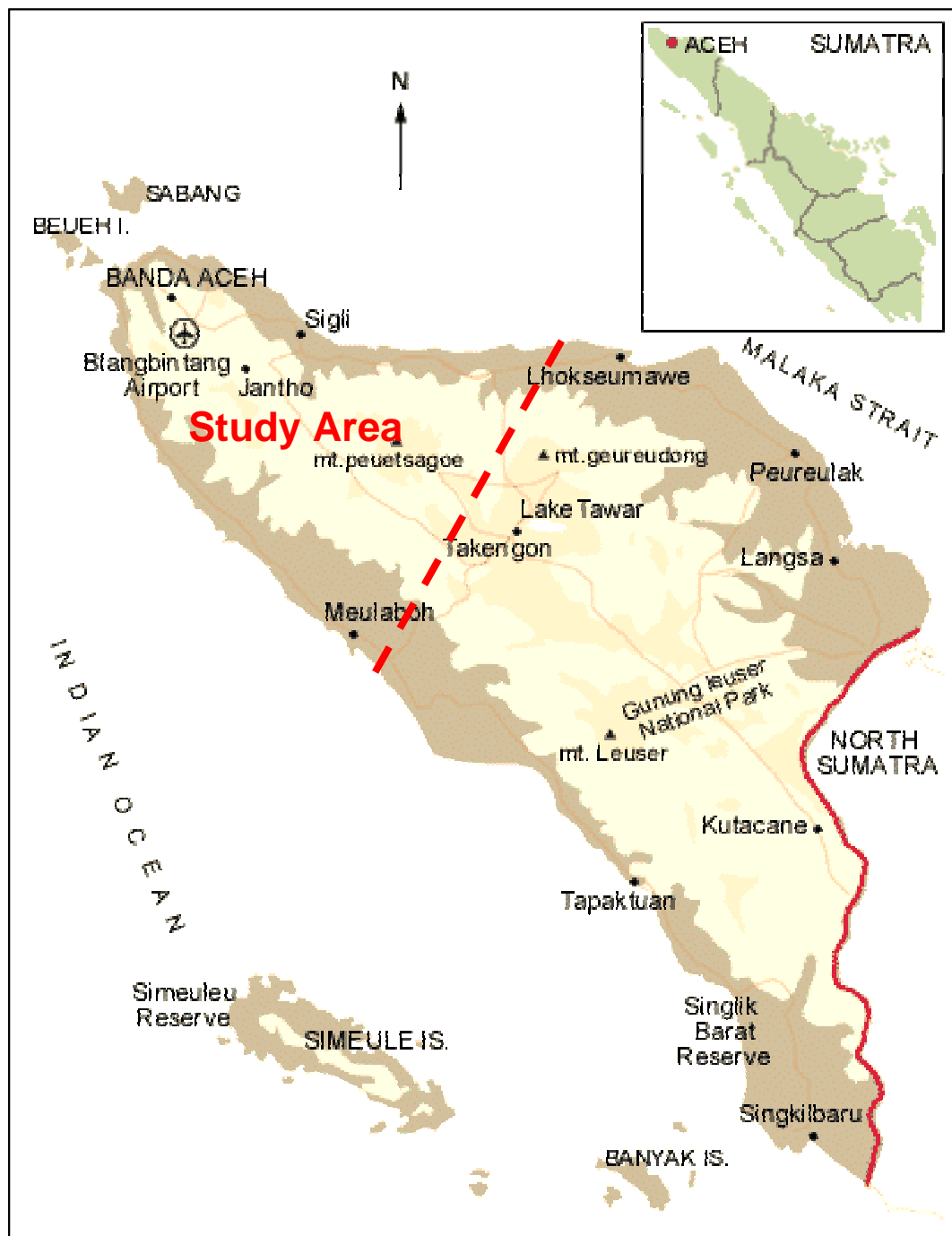


Figure 2a. Location of Aceh Province. The capital, Banda Aceh is located in a low area to the north. Low lying areas are shown in darker brown

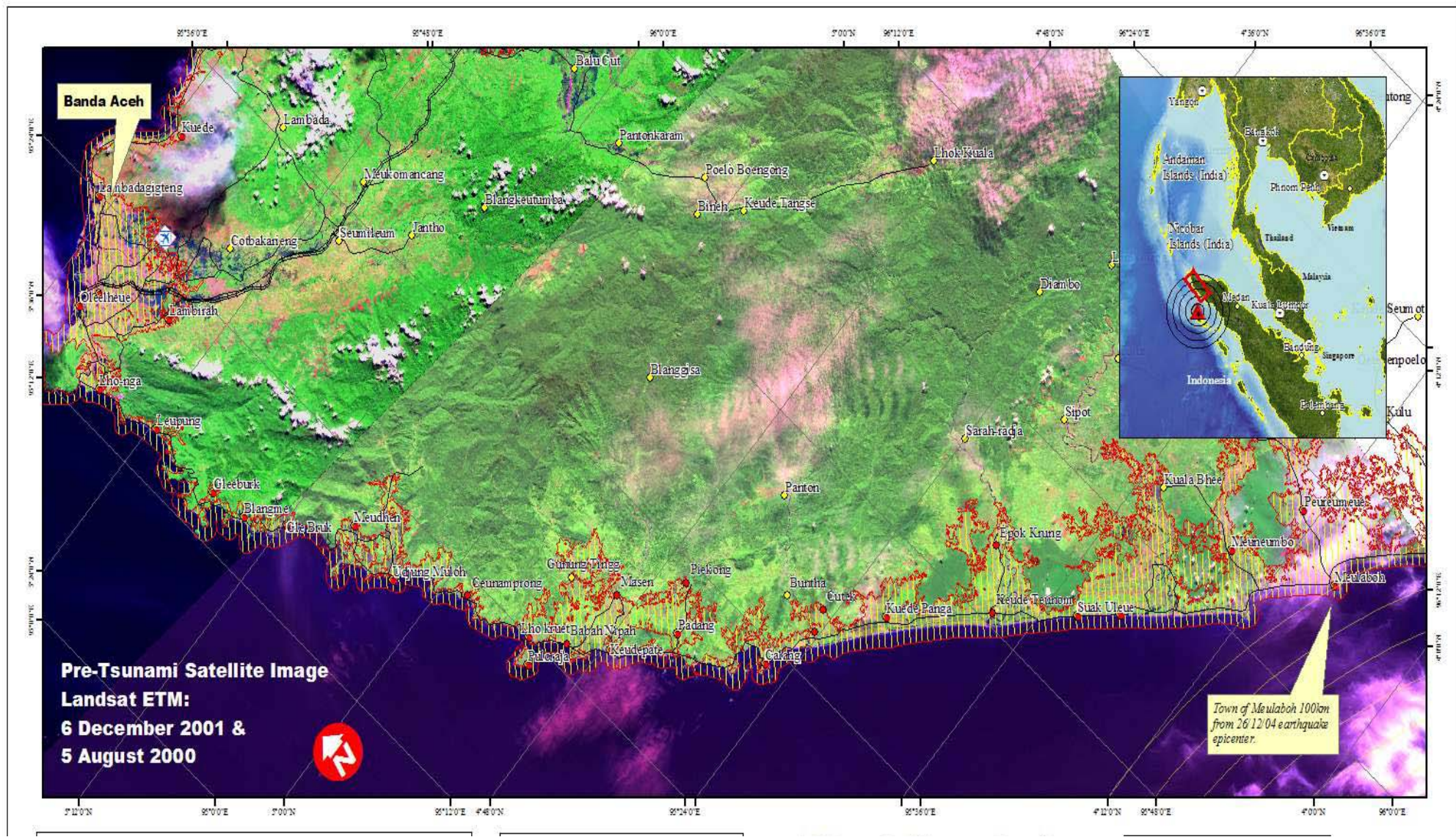


Figure 2b. West coast of Aceh, Indonesia. This image map shows the major towns and geographic character of the area. The Landsat image was from GLCF and the map was produced by the United Nations UNOSAT at http://unosat.web.cern.ch/unosat/asp/prod_free.asp?id=55

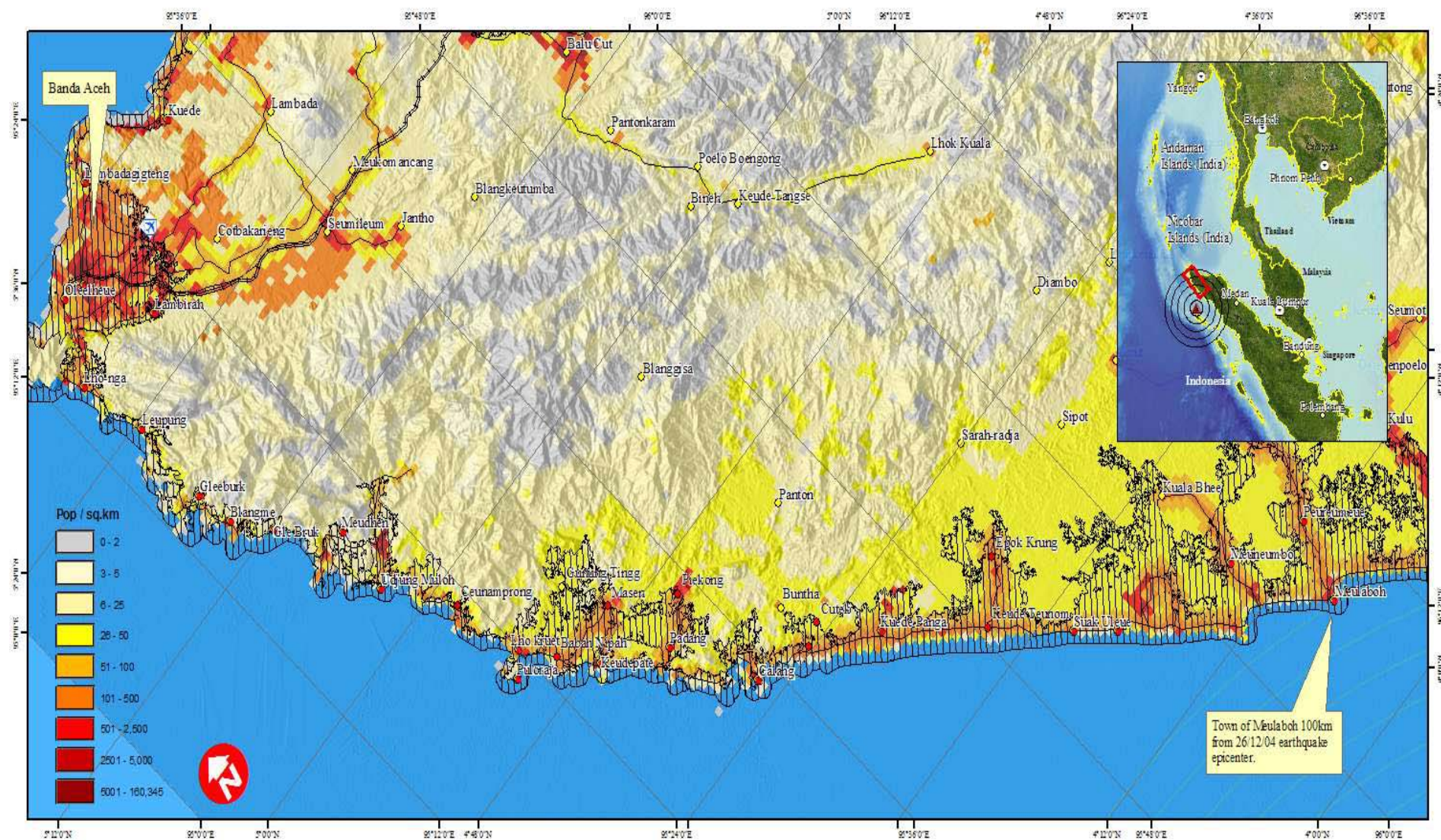


Figure 3. Population density in Aceh. Map provided courtesy of the United Nations UNOSAT. Web site: http://unosat.web.cern.ch/unosat/asp/prod_free.asp?id=55

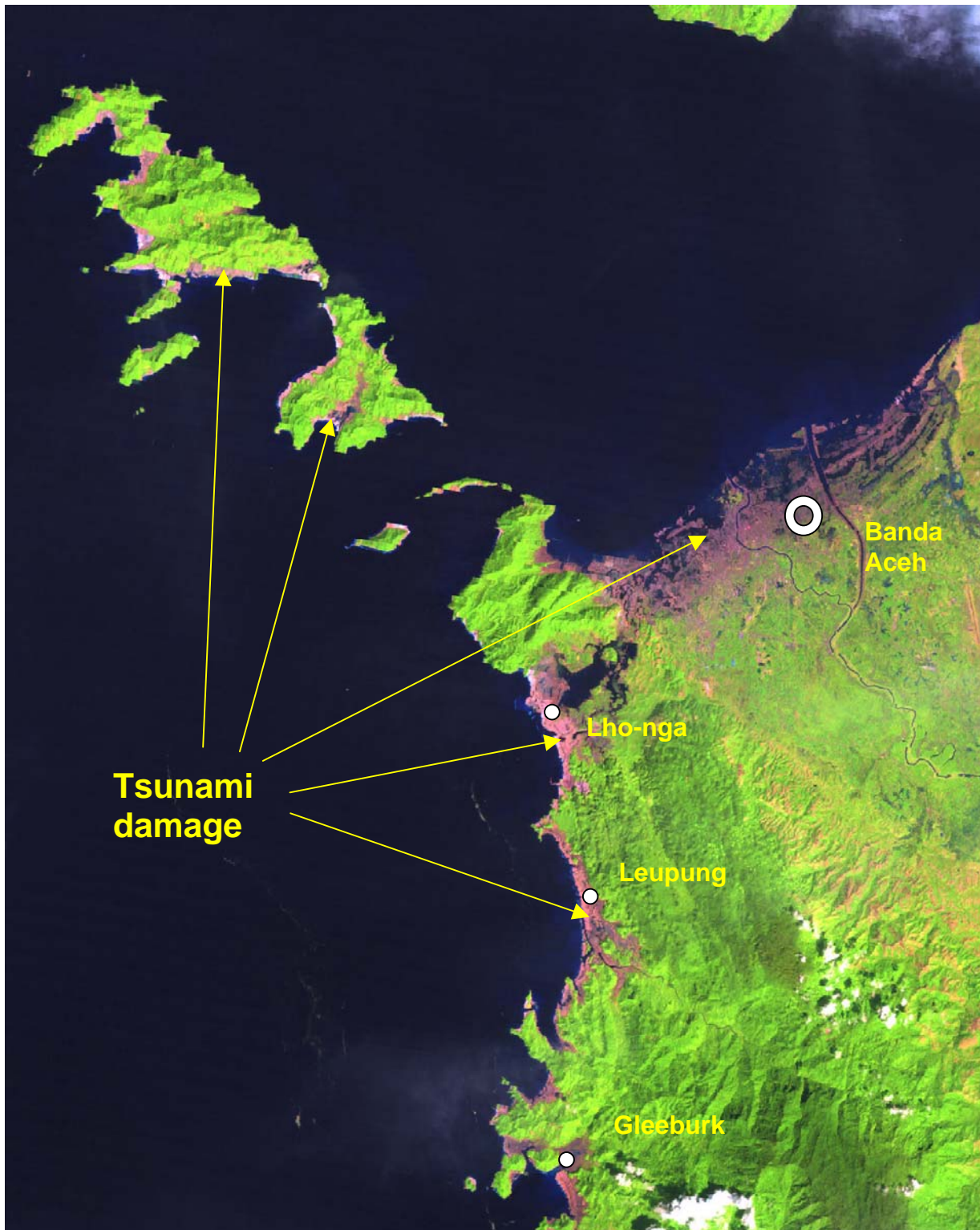


Figure 4. Image showing damage in reddish tones along coastline. Very hard hit cities of Banda Aceh, Lho-nga, Leupung and Gleeburk. The “lake” created behind Lho-nga is indicative of significant inundation and flooding.

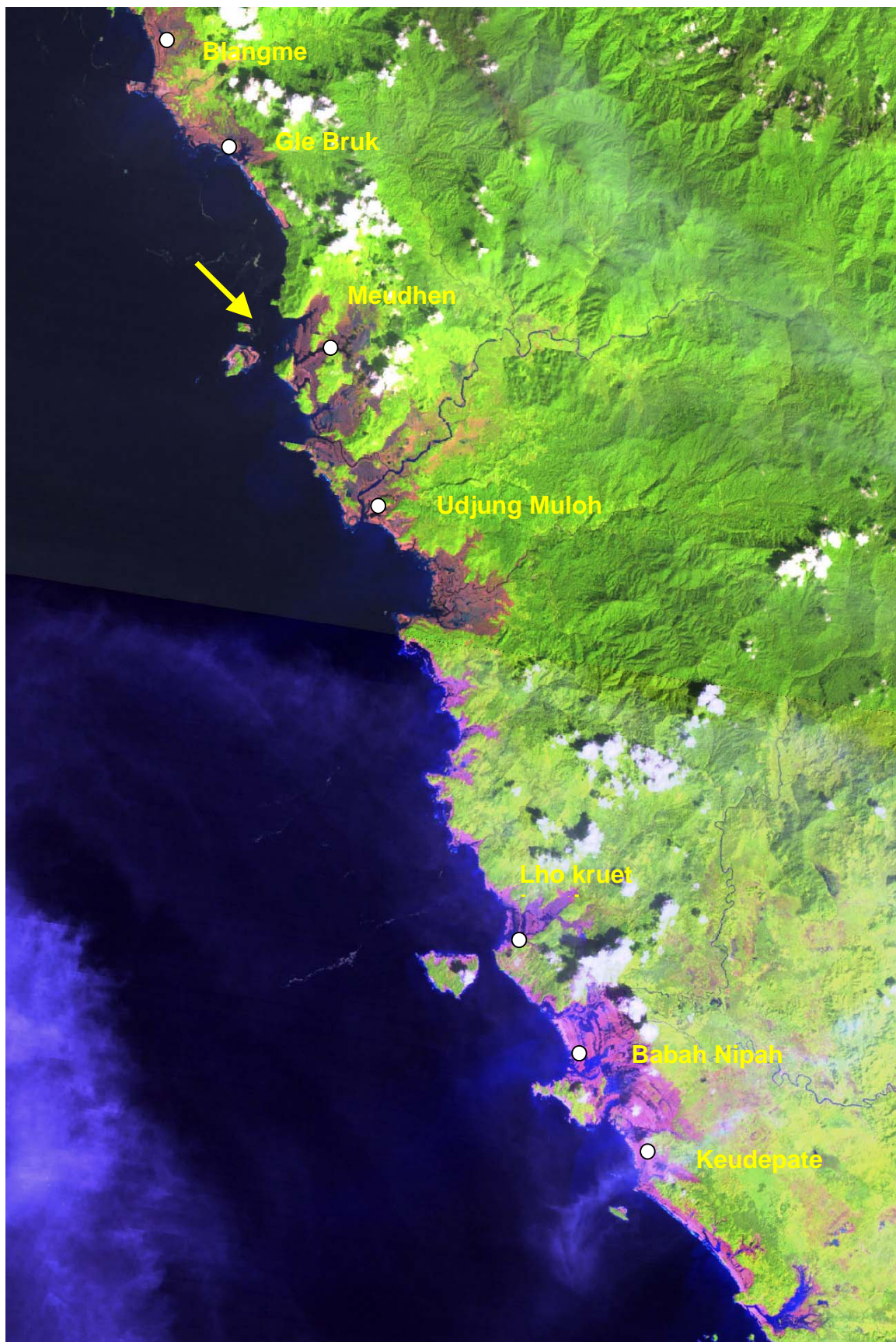


Figure 5. This image map is directly to the south of Figure 4. Note the coincident proximity of major towns and inundated/low areas. The flooding affected the highest density populations in part because population centers are located in hazard areas. Particularly hard hit is in the vicinity of Baba Nipah. Note the arrow pointing to an island which was once connected to the mainland.

Before

After

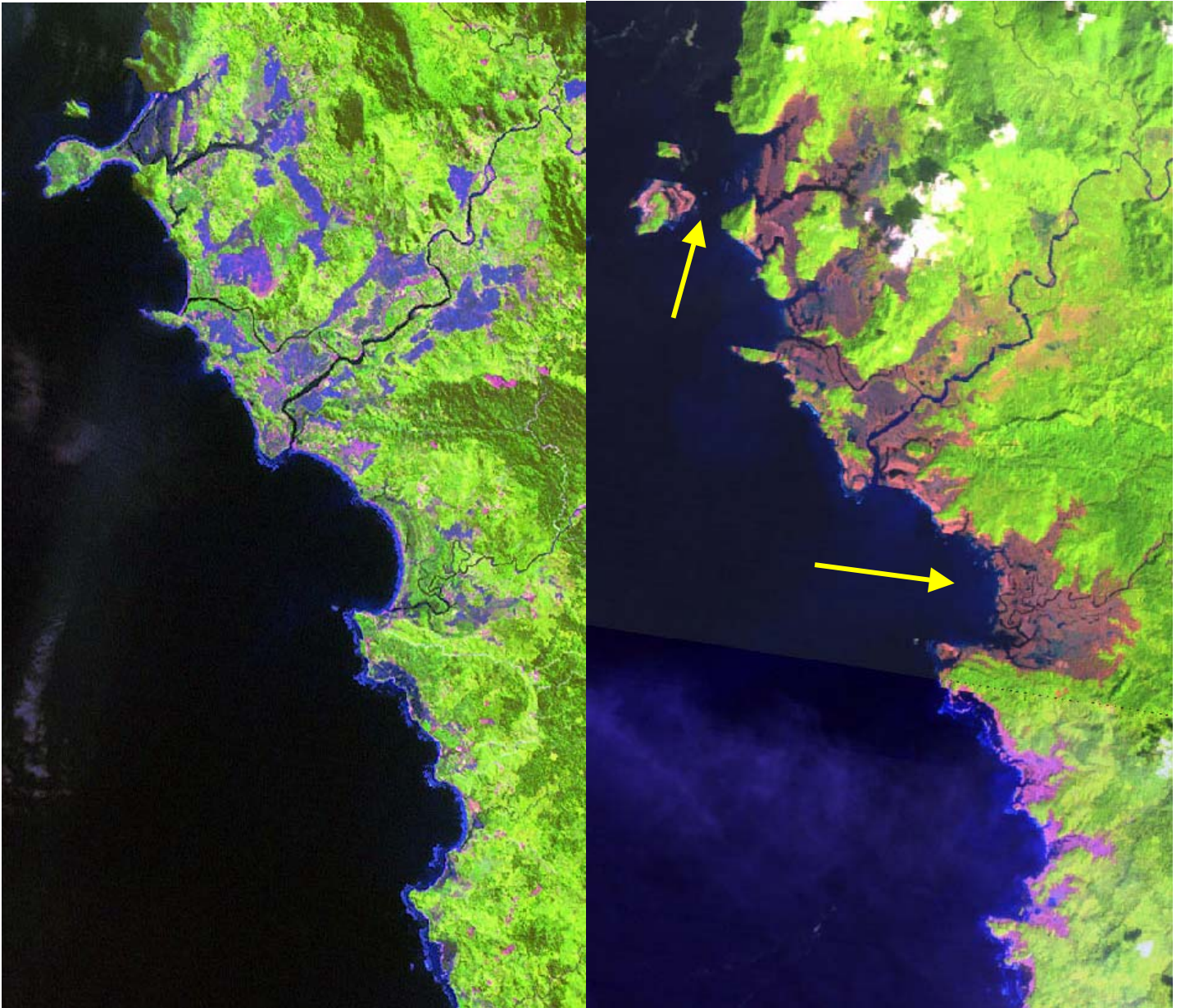


Figure 6. Close up views with before and after comparisons. Note the arrows which show significant erosion and destruction of coastline. There appears to be “pockets” of high impact – certain areas were “targets” of much higher impact than others – and these align with the location of cities and populated areas.

Before



After



Figure 7. Localized close up view of the coastline around the hard hit city of Babah nipah. Note the significant erosion and “roughening” of the coastline and significant flooding. As seen before there are significant pockets of impact and the effect of the tsunami was not uniform.

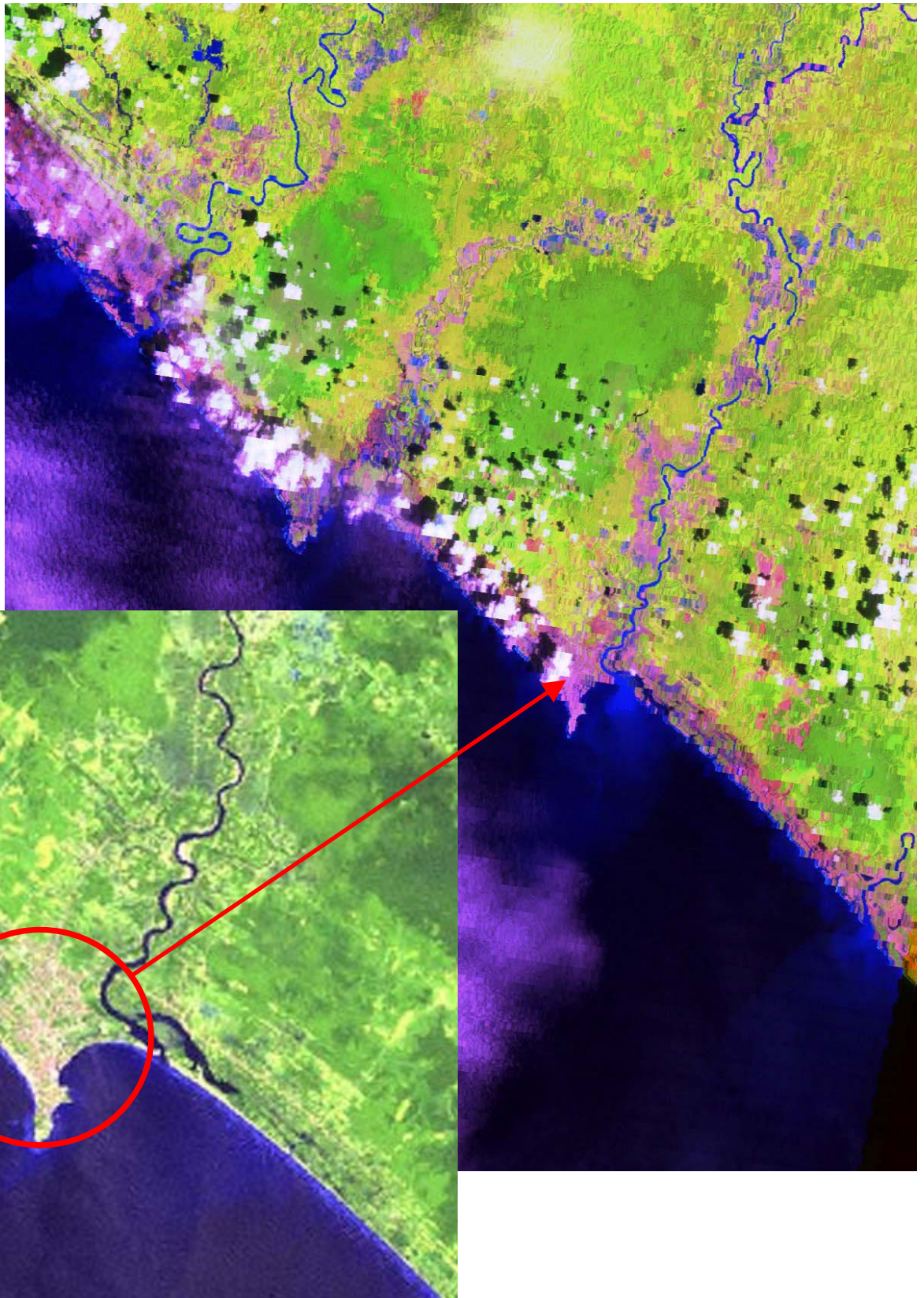


Figure 8. A comparison of before and after the tsunami shows the complete inundation around the city of Meulaboh. This is of particular concern because it is a major population center which has been completely devastated. The reddish tones on the large post-tsunami image are inundated areas. The inset shows an enlargement before the tsunami. The pink tones show built areas of the city.

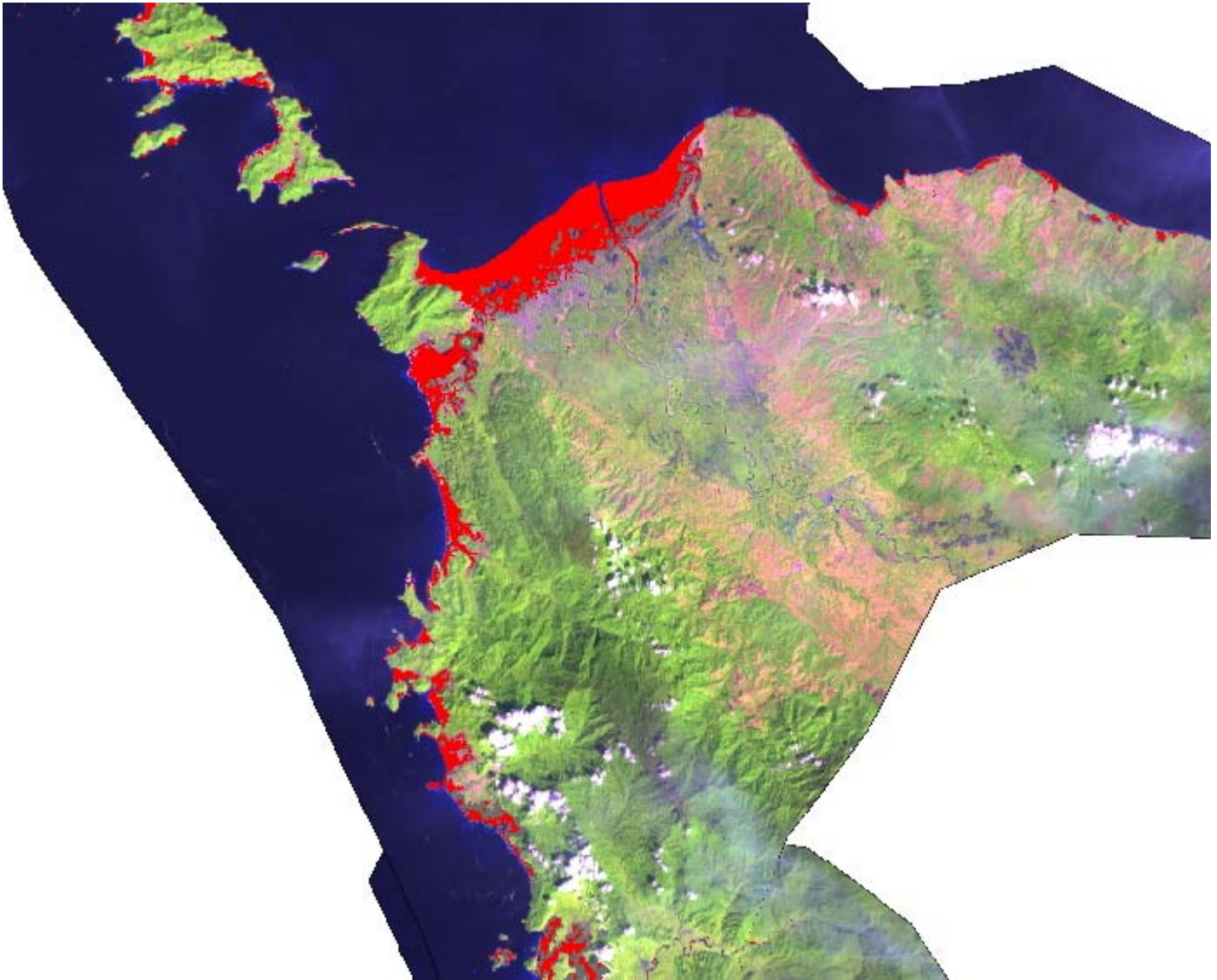


Figure 9. Red areas are our assessment of damage for the northern area around Banda Aceh.

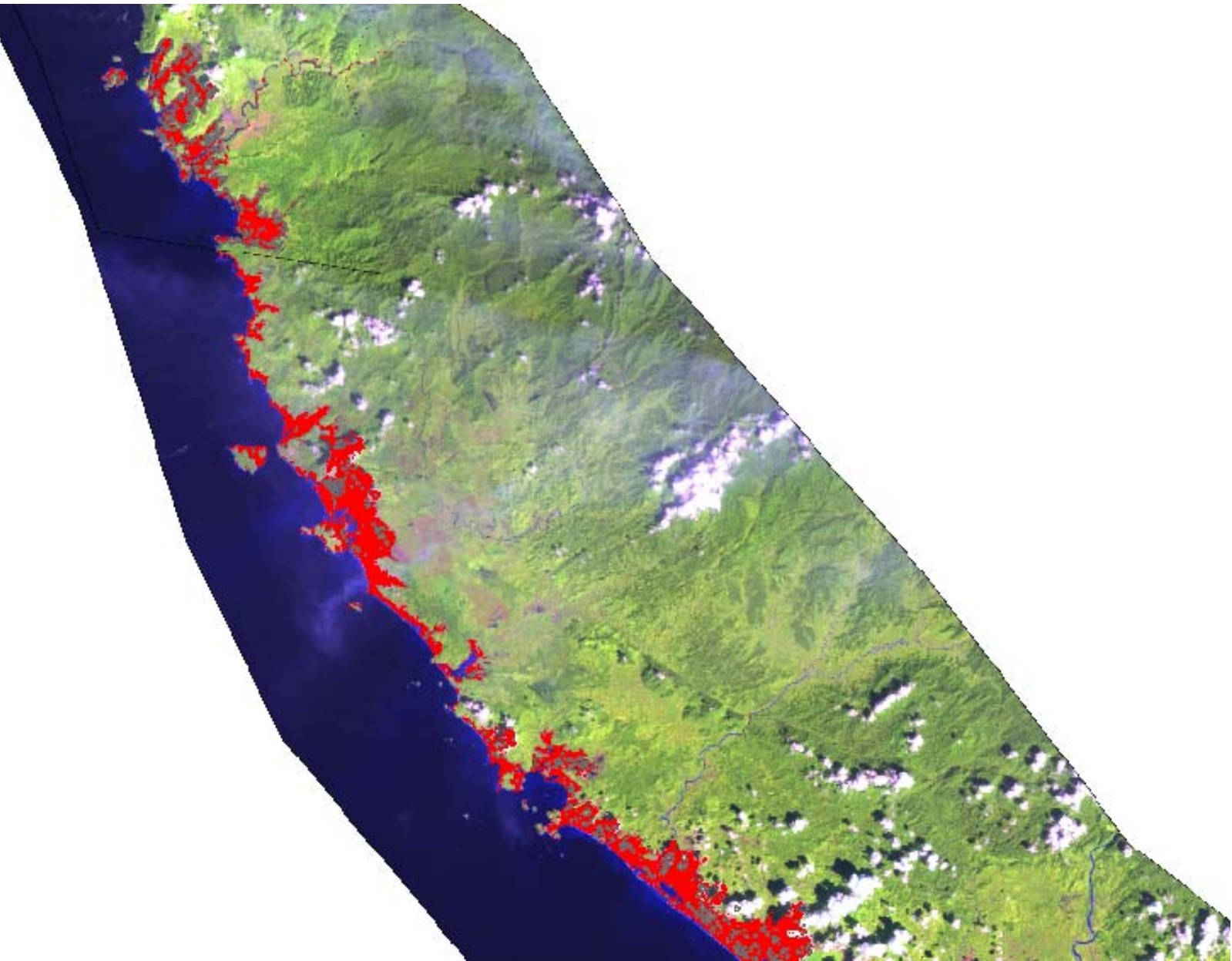


Figure 10. Damage assessment for the mid-region.

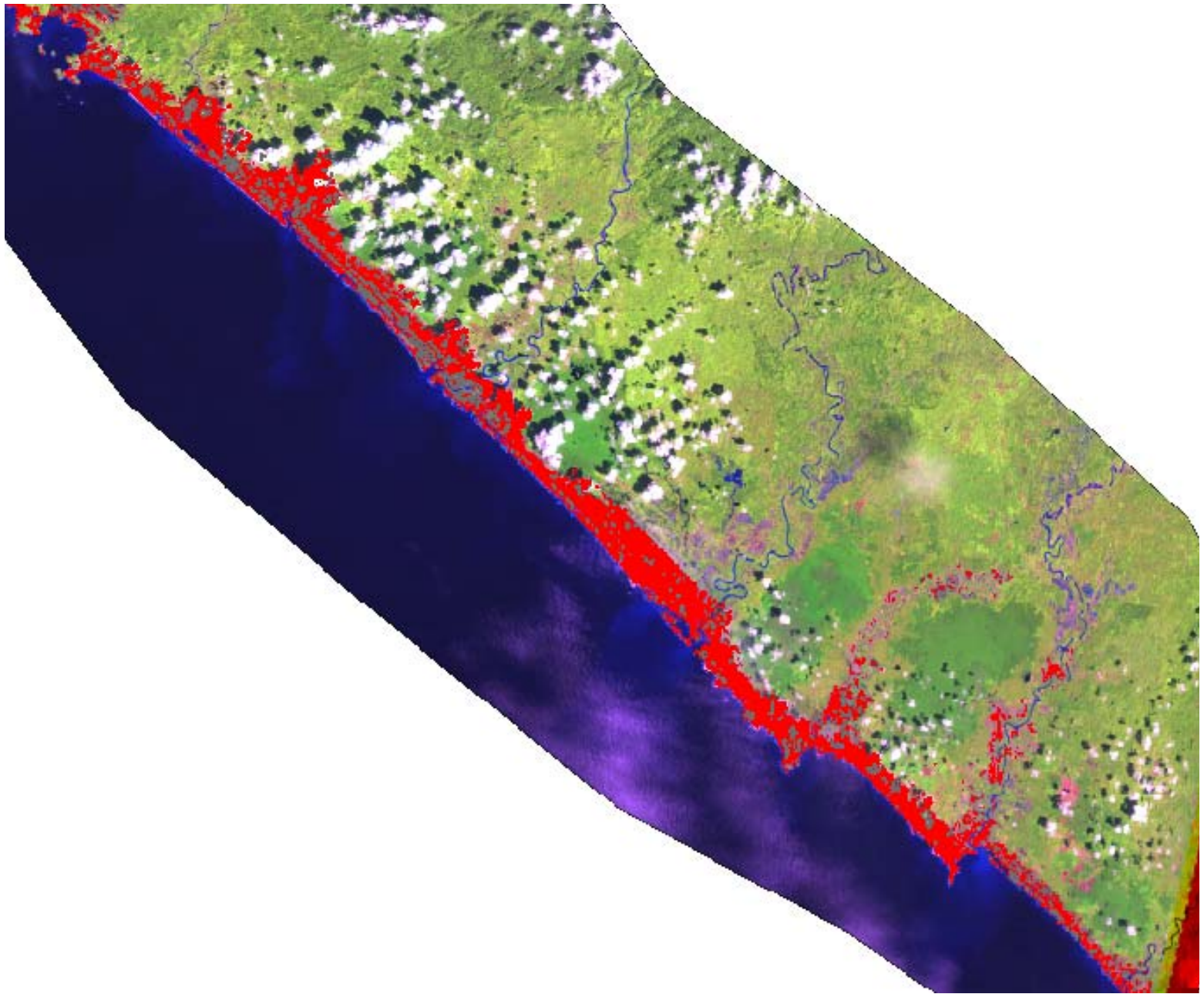


Figure 11. Damage assessment for the southern portion of the study area, close to city of Meulaboh



Figure 12. Close up of the Banda Aceh area.